# Patent and publishing activity sequence over a technology's life cycle

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## ABSTRACT

The use of multiple indicators in analyzing technological developments and exploiting the increasing availability of information has been recommended widely in order to decrease systematic biases between single measures. One of the few frameworks that take multiple sources into account is the Technology Life Cycle indicators that provide a measure for the totality of sources available for analysis and take their timeliness into account, although the linear model that the framework represents is often questioned. The aim of this paper is to provide bibliometric studies with insight into the timely relevance of using different databases. To assess the reporting sequence between different databases, this paper measures the reporting activity of three case technologies in different databases and analyzes the yearly reporting volumes of a number of items that mention the technology in the databases as suggested by the TLC indicators. The results of this paper suggest that, when science is the source of new ideas and the driver for technological development and innovations, communication can happen in the order suggested by the TLC indicators. However, this model does not seem to be a general model for detecting and forecasting a technological life cycle. In addition, the results of the paper point to the possibility of studying non-linear models of innovation and contexts where this type of dynamics might take place.

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## 1. Introduction

The purpose of technological forecasting is to provide timely insight into the prospects of technological change [1]. In analyzing technological developments, and exploiting the increasing availability of information, bibliometric studies have especially increased in popularity in technological forecasting. In the current literature, however, bibliometric studies are often scientometric studies that rely typically on only a single source such as the Science Citation Index or Compendex to analyze scientific advancements. The use of these sources is so common that bibliometric analysis is even said to be applicable if international journals are the dominant or at least a major means of communication in a particular field under investigation [2]. Similarly, in technological forecasting, patent analyses have been among the most prevalent measures of innovation, although there is a debate in the literature regarding possible problems with using patent data to measure innovation or technological progression, such as Griliches's concept of the "mirage" of patent statistics, which appear to provide a number of proxy measures for analysis that may not be real [3]. In summary, one of the most prolific criticisms concerning technological forecasting, and specifically the use of databases, is the use of one database as a source, which has been noted to lead to biased results, as one database reveals only one side of the story [4]. The often-stated recommendation is to use multiple sources to overcome the biases and weaknesses of single sources [4,5].

In an effort to understand the timeliness of different sources and to remedy the maladies of using a single source, the concept of Technology Life Cycle indicators [1] was created. Technology Life Cycle (TLC) indicators create a holistic picture of the multiple sources used in reporting the various findings in each stage of R&D. TLC indicators suggest an indicator, the number of articles, for

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each of the R&D stages: the Science Citation Index for basic research, the Engineering Index for applied research, Patents for development, Newspapers for application, and finally the Business and Popular Press for the societal impact stage of R&D. The TLC indicators were developed for technology forecasting, and as the name suggests, the purpose is to track the life cycle of the technology with an indicator pointed for each stage. Nevertheless, the theoretical basis for technological forecasting lies in understanding the processes of technological innovation, and the TLC indicators clearly rely on the heavily criticized linear model, a model that has been even claimed to be "dead" [6], but nevertheless used for its simplicity [7], and for that, the model is a "rhetorical entity" and "gives a sense of orientation when thinking about funding to R&D" [7]. The criticism pointed at the linear model of technological innovation is also valid for the TLC indicators in terms of the claimed order, and an over-emphasis on science as the origin of innovations and technologies. Nevertheless, the TLC indicators as a concept comprise the databases that are the most frequently used in the literature, a means for measuring technological progression in these sources, and finally the relationship between the different sources.

The TLC indicators concept is thus taken as the starting point for this study, as a joint assessment of the magnitude of reporting the technological progression in these databases would help the bibliometric analysis of emerging technologies in technological forecasting. Therefore, the purpose of this paper is to provide assistance to the measurement concerning the temporal evolution of reporting the technological progression in each of the databases as suggested by the TLC indicators. The aim is to provide bibliometric studies with insight into the timely relevance of using different databases, and the following research question emerges for this paper: Do the sources suggested by the TLC indicators to report about a technology follow a sequence that starts with scientific papers, followed by engineering papers, then patents, and finally news? The research question is symmetrical in the way that positive and negative answers will add to our knowledge and help the future of bibliometric studies, especially in relation to technological forecasting.

To assess the reporting sequence between different databases, this paper measures the reporting activity of three case technologies in different databases and analyzes the yearly reporting volumes of the number of items mentioning the technology in the databases as suggested by the TLC indicators. The study provides insight into the orderliness of the publication activity in different databases and hence sheds light on the theoretical grounding of the TLC indicators. In addition, the paper seriously questions the traditional use of only one source in technological forecasting studies.

## 2. Theoretical background

The purpose of technological forecasting is to provide timely insight into the prospects of technological change [1]. Forecasting research does this by analyzing the past and present, and then forecasting the future. For the analyses of the past and present, information about technological innovations is needed, and this information is commonly tracked from different databases over the technology's life cycle. A method for analyzing text databases quantitatively is bibliometrics, defined as a general means for measuring texts and information [8,9]. Bibliometric analyses help researchers identify "who is doing what and where," give insight into where the technological development is heading, and provide feasible rates of progress along with warning signals of what is to come [10].

As the amount of information available in electronic form continues its logarithmic growth, the number of studies analyzing that information grows. When looking at the ISI Web of Knowledge the number of studies that at least mention bibliometrics has grown steadily since the 1980s (Fig. 1). This is not surprising as information technology has enabled and facilitated a mass of information to reach us; each year, the amount of printed and digital information created in companies grows faster than 65% [11]. This amount of information has thus much potential to be mined and analyzed, also from the technology forecasting point of view.

While more and more databases and electronically accessible sources are available to be bibliometrically analyzed, most of the technology-oriented analyses use only one database as a source [12–14]. In scientometric orientation, the source used is often the Science Citation Index (SCI) or Compendex; these indexes focus on journal publications, and the latter includes conference papers. The Science Citation Index is said to be one of the best sources for publication and citation data [15,16] and is often used as a
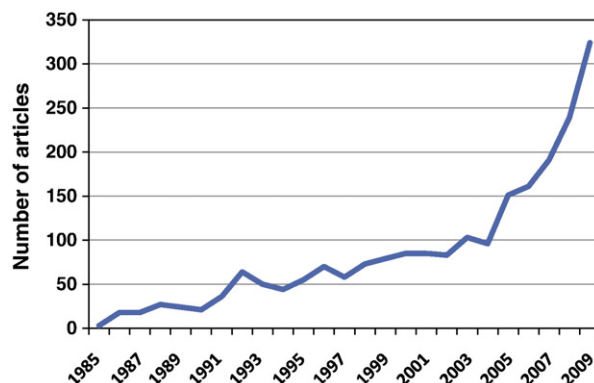


**Fig. 1.** "Bibliometric*" in the TOPIC field of ISI Web of Science databases.